15. Determination of the Density Change of Glass by the Sink-Float Method. (IV)

Density of Glass Subjected to Different Heat Treatment

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For the purpose of obtaining some exact data on the change of the density of glass affected by the different thermal history, the density of a soda-lime glass of a definite composition (cf. this Bull. **19**, 52 (1949)) was measured by the sink-float method after being subjected to different heat treatments.

In an attempt to make clear the effect of the shape and size of samples, the glass spheres and slabs of different sizes were cooled in air from just above the softening point. Their density-size curves were found to be nearly parallel each other, which also were in the same relation with those obtained with the glass rods (cf. this Bull. **24** 71 (1951)). The values, however, are affected appreciably by the shape of samples and, in the range of the size of 3–6 mm, for example, the density of sphere is smaller by about $15–20 \times 10^4$ g/cm^3 than that of slab. These relations can be explained, at least qualitatively, by taking into account the ratio of the volume and the cooling surface of the samples.

The density of oil- and water-quenched samples was found to be smaller than that of rod-as-drawn, 3–6 mm. in thickness by 0.2–0.3% ($55–70 \times 10^{-4}$ g./cm.^{3}) and by 0.6–0.8% ($150–200 \times 10^{-4}$ g./cm.^{3}) respectively. The densities of such intensely quenched samples have shown the increase by reheating at the temperature far below its lower annealing point (ca. 430°C). A water quenched sample, for example, has proved the increase in density at the third decimal place by heating for an hour at the temperature so low as 100°C. The densities of all quenched samples, regardless the quenching conditions, recoverd almost instantaneously to that of rod-as-drawn by heating at the higher temperature than 400°C.

The density of these rapidly cooled samples, after having been reheated for a definite time t at different temperatures and cooled in air, was found to reach a maximum value D_m when heated at a certain temperature T_m. The maximum density D_m (g./cm.^{3}) and the temperature T_m (°C), at which the maximum density occurs, vary with the holding time t (minute) for compacting according to the equations: $D_m = D_{m.1} + d \cdot \mathrm{Log}_{10}\, t$ and $T_m = T_{m.1} - c \cdot \mathrm{Log}_{10}\, t$, where $D_{m.1}$, d, $T_{m.1}$ and c are constants, having the values 2.4920 (g./cm.^{3}), 0.0024 (g./cm.^{3}), 527°C and 18°C respectively.

It was confirmed that these formulae hold good even if the reheating was continued as long as 4×10^4 minutes (ca. 1 month). Hence it may be said that the perfectly stabilized (compacted) state of glass in the strict sence of the word is practically unattainable.